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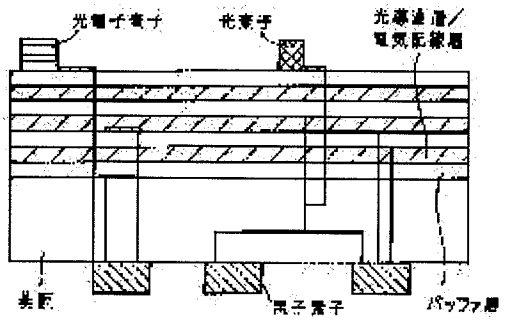
(54) ELECTRONIC OPTICAL CIRCUIT

(57)Abstract:

PURPOSE: To simplify waveguide wiring in an optical circuit by providing optical devices and electronic devices and/or photoelectronic devices on both surfaces of a board and connecting to respective devices at least a part of optical waveguide and electrical wirings formed on the both surfaces of the board.

CONSTITUTION: Optical devices such as semiconductor laser, LED, photodiode, etc., or photoelectronic integrated circuits are fixed on the upper surface of a board where light a waveguide is formed, while electronic devices such as ICs, etc., are fixed on the lower surface of the board where electrical wiring are prepared. Then the both surfaces are connected by means of electrical wirings or optical wirings communicating each other in the board, an optical waveguide and an optical fiber are connected on the surface of an optical circuit, and optical waveguide devices and optical devices are integrated to constitute an electronic optical circuit at the same time. Further, when the optical waveguide is constructed by nonlinear optical effect materials such as pendant- added type polymer, etc., optical switches, modulators, etc., can be built in the board, thereby enabling flexible optical wiring.



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CLAIMS

[Claim(s)]
[Claim 1] The electronic optical circuit where it comes to equip both sides of a substrate an optical device, and an electron device and/or a photoelectron device, optical waveguide and electric wiring are formed in both sides of a substrate, and at least the part is connected to said device.
[Claim 2] An optical device Semiconductor laser, LED, a photodiode, a photo transistor, It is the multi chip module which carried at least one or it which was chosen from the optical fiber, the holographic optical device, the optical modulator, and the optical switch. It is the multi chip module or board on which the electron device put a semiconductor integrated circuit or two or more semiconductor integrated circuits. [whether it is the OPUTO-electro nick integrated circuit with which the photoelectron device accumulated the optical device and the electron device on the chip, and] Or the electronic optical circuit according to claim 1 which is the multi chip module or board which carried an optical device, an electron device, and two or more kinds of devices chosen from OEIC.
[Claim 3] The electronic optical circuit characterized by equipping with an optical fiber on an optical circuit, and making connection between optical waveguide and an optical fiber in the optical circuit where optical waveguide or optical waveguide, and electric wiring were formed on the substrate, and connecting between optical waveguide, an optical device, and/or photoelectron devices with an optical fiber.
[Claim 4] The electronic optical circuit where optical amplification waveguide was further formed in any 1 term of claims 1-3 in the optical circuit of a publication.
[Claim 5] Claims 1, 2, and 3 or 4 electronic optical circuits which come to form the electrode for equipping with a photo detector or a photo detector, and a light emitting device, and receiving the input/output terminal of an electronic device on the optical circuit substrate in which optical waveguide was formed.
[Claim 6] The electronic optical circuit characterized by making the optical circuit exterior carry out outgoing radiation of a part of guided wave light [at least] from the waveguide in an optical circuit by refractive-index change produced in electrical-potential-difference impression in the electronic optical circuit which the optical switch or the modulator was made to correspond to the output terminal of an electron device or a photoelectron device, and formed it, and sending data.
[Claim 7] The electronic optical circuit to which the optical circuit exterior is made to carry out outgoing radiation of an optical switch or the light by which light modulation was carried out from the waveguide in an optical circuit by refractive-index change which is the electronic optical circuit which the optical switch or the modulator was made to correspond to the output terminal of an electron device or a photoelectron device, and formed it, and was produced in electrical-potential-difference impression, and data were sent.
[Claim 8] The optical switch characterized by arranging and consisting of optical waveguide in the optical switch which switches light to other optical waveguides using the Pockels effect or the optical Kerr effect as at least one waveguide in the waveguide concerning an optical switch has a different mode number from other optical waveguides.

[Claim 9] The channel mold optical waveguide 3 is arranged so that the gap of the channel mold optical waveguides 1 and 2 which countered in the shape of a straight line, and these waveguides 1 and 2 may be made to pass a part of outgoing radiation light at least. The optical-path sensing element carries out incidence of the light coherent on the same wavelength to optical waveguide 1 (or 2) and optical waveguide 3, and makes a hologram form in a field including the above-mentioned gap, and it was made to make an optical path change into optical waveguide 2 (or 1) from the optical waveguide 3 from optical waveguide 2 (or 1), or optical waveguide 3.
[Claim 10] It is the mode transformation component which the channel mold optical waveguides 1 and 2 consider as the waveguide which has the same mode number, and changed the mode of light in claim 9 as waveguide which has the mode number in which the channel mold optical waveguide 3 differs from optical waveguides 1 and 2.
[Claim 11] The optical-path sensing element the channel mold optical waveguide 2 is arranged so that in parallel with the channel mold optical waveguide 1 and this waveguide, and carries out incidence of the light coherent on the same wavelength to such optical waveguides 1 and 2, and makes a hologram form in the overlap part of both light, and it was made to make an optical path change into waveguide 1 from the optical waveguide 2 from optical waveguide 1, or waveguide 2.
[Claim 12] The mode transformation component to which it was made to carry out mode transformation of the light as it had the mode number from which the channel mold optical waveguide 1 and the channel mold optical waveguide 2 differ in claim 11.
[Claim 13] The optical-path sensing element which arranges the channel mold optical waveguide 1 and the slab mold waveguide 2, was made to carry out incidence of the light coherent on the same wavelength to optical waveguides 1 and 2, is made to form a hologram in the overlap part of both light, and was made to make an optical-path change to optical waveguide 1 from the optical waveguide 2 from optical waveguide 1, or optical waveguide 2.
[Claim 14] The mode transformation component to which it was made to carry out mode transformation of the light as it had the mode condition that the channel mold optical waveguide 1 differs from a channel waveguide 2, in claim 13.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] About an electronic optical circuit, in more detail, this invention is rich in flexibility and relates to the electronic optical circuit which can respond to a complicated interconnection.
[0002]
[Description of the Prior Art] An optical circuit begins the optical interconnection and the optical exchange of a computer, and it is as being known well to play an important role in various optical systems. An example of the typical optical circuit by which the conventional proposal is made is shown in drawing 1 . In this example, between electronic devices, such as IC and a multi chip module, is combined by optical waveguide, and signal transduction is performed. However, in this optical circuit, if the number of ICs increases and connection becomes complicated, it will become important to produce the need of making waveguide crossing frequently, and to take an interface with semiconductor laser or a photodiode smoothly. Moreover, although large refraction of waveguide must be taken if the number of ICs increases and connection becomes complicated, in the single mode waveguide usually used now, it is difficult to enlarge deflection of waveguide. On the other hand, when it was going to give the optical switch and the light modulation function to waveguide, there was dilemma that single mode waveguide was desirable. Furthermore, on the substrate, electron devices, such as IC for driving a waveguide optical switch and an optical modulator and amplifier of an input signal, become jostling, and pose a big problem also from on mounting.
[0003] Moreover, in an optical interconnection etc., although it is desirable for there to be an optical amplifier function, now, as optical amplifier, the thing of a fiber configuration is most like Er dope fiber or Pr dope fiber, and there is a problem that application to an optical circuit is difficult.
[0004]
[Problem(s) to be Solved by the Invention] This invention solves the trouble of the above mentioned conventional electronic optical circuit, and it is rich in flexibility, and aims at offering the electronic optical circuit which can respond to a complicated optical interconnection.
[0005] This invention arranges an electronic device and OEIC and aims at offering the simple electronic optical circuit which can perform optical connection only by performing electric contact again.
[0006] This invention aims at offering the electronic optical circuit which can simplify waveguide wiring in an optical circuit by exchanging light among further two or more optical circuits.
[0007]
[Means for Solving the Problem] In the first mode of this invention, the above-mentioned problem is solvable by equipping both sides of a substrate with an optical device, and an electron device and/or a photoelectron device, and introducing a multilayer circuit further.
[0008] In the second mode of this invention, conventionally, by making connection with the optical waveguide and the optical fiber which were performed from the optical waveguide end face make on an optical circuit front face, unifying a waveguide device and a fiber device, and connecting with the

electronic optical circuit of further others, an optical amplification fiber can be attached still more preferably and the above-mentioned problem can be solved by amplifying the light of a required part in an optical circuit.
[0009] In the third mode of this invention, the above-mentioned problem is solvable with the electronic optical circuit to which the optical circuit exterior is made to carry out outgoing radiation of a part or all of guided wave light from the waveguide in an optical circuit by refractive-index change produced in electrical-potential-difference impression, and data were sent in the electronic optical circuit which the optical switch or the modulator was made to correspond to the output terminal of an electronic device, and formed it.
[0010] In the fourth mode of this invention, the above-mentioned problem is solvable with an optical switch again by performing mode transformation and optical-path conversion with a waveguide hologram ingredient by changing a mode number suitably for every location of an electronic optical circuit.
[0011] In the fifth mode, the electrode for forming (i) optical amplification waveguide, and equipping with amplifying the light of a required part in an optical circuit or the (ii) photo detector and a light emitting device, and the fiber for supplying light further, and receiving the input/output terminal of an electronic device can be formed, and only by placing the usual electronic device and carrying out electrical installation, when it can be made to perform optical connection, the above-mentioned problem can be solved.
[0012]
[Example] It cannot be overemphasized that it is not what limits this invention to the following examples hereafter although an example explains this invention still more concretely.
[0013] An example of the first mode of this invention was notionally shown in drawing 2 . The top face of the substrate in which optical waveguide was formed is equipped with optical devices (light corpuscle child) and photoelectron accumulation devices (photoelectron component (OEIC)), such as semiconductor laser, LED, a photodiode, a photo transistor, an optical fiber, a holographic optical device, an optical modulator, and an optical switch, on the substrate inferior surface of tongue where an electronic device (for example, IC) has electric wiring. The top face and inferior surface of tongue of a substrate are connected with the electric wiring or optical wiring which penetrated the substrate. In addition, in drawing 2 , an electronic device may live together on the top face, and the light corpuscle child and the photoelectron accumulation device may live together on the inferior surface of tongue. Moreover, as shown in drawing 3 , optical waveguide (and electric wiring) may live in the field of another side of electric wiring and a substrate together in one field of a substrate.
[0014] A part of such electric wiring and optical waveguide [at least] are connected to the device, the electric wiring on a substrate side may be a multilayered circuit board (for example, crystallized glass multilayered circuit board), and optical wiring may be a multilayer optical circuit. Moreover, when it constitutes a part or all of optical waveguide from nonlinear optical effect ingredients, such as for example, a pendant addition mold polymer, a principal chain mold polymer, and a conjugation polymer, an optical switch, a modulator, etc. can be built into a substrate and flexible optical wiring is attained. It can equip with the multi chip module which comes to accumulate two or more optical devices, two or more electron devices, and/or two or more photoelectron accumulation devices on a chip on a substrate. It can also equip in the form where the board which carried the electron device, the optical device, and/or the photoelectron device was built.
[0015] A double-sided circuit which was described above is producible with the patterning process using a double sided aligner by the technique (for example, refer to Japanese Patent Application No. No. (March 6, Heisei 4 application) 48961 [four to]) of multilayer optical circuit formation, after forming for example, inferior-surface-of-tongue electric wiring and the electric wiring for connection between an inferior surface of tongue and a top face with the conventional circuit board technique. In addition, a buffer layer has little light absorption, and if a polymer, the inorganic film, etc. are matter with a refractive index smaller than the waveguide section, it can constitute them from an ingredient of arbitration.

[0016] An example of an electronic optical circuit which followed drawing 4 at the second mode of this invention was shown notionally. Although this example showed the example of multilayer waveguide structure, it is not necessary to necessarily consider as multilayer structure. In this mode, all or a part of association of optical devices, such as semiconductor laser, a photodiode, a photo transistor, and an optical switch, and waveguide is performed through the optical fiber (an optical-fiber ribbon or a handle is included) of the quality of the materials, such as a quartz and a polymer. In that case, the optical circuit side is beforehand equipped with the optical fiber, and the fiber which connected the optical device with it or was connected to the light corpuscle child is connected on an optical circuit side. Or it connects on the optical-path side which equips an optical circuit side with a fiber beforehand, and connects the fiber also to the light corpuscle child, and connects them. It can be based on the approach which used for connection of a fiber and waveguide the hologram as shown in the optical switch explained later. The component with which it equips on a substrate can be made into the multi chip module which comes to accumulate an optical device, an electron device, a photoelectron device, two or more optical devices, two or more electron devices, and/or two or more photoelectron accumulation devices on a chip. Moreover, it is good also as a board which carried these. In this case, as for a board, building and installing to an optical circuit side is desirable.
[0017] Moreover, an optical amplification fiber is taken out from an optical circuit side, as shown in drawing 4 , and it is pump light (for example, in the case of thulium dope glass fiber, -680nm amplifies the light near 800nm with pump light.). In the case of erbium dope glass fiber, it is with the pump light near 1 micrometer. By amplifying the light near 1.5 micrometer by magnification, and returning to an optical circuit side, optical amplification can be performed in a required part. Since the burden to the electric magnification after photo electric conversion decreases by this or electric magnification becomes unnecessary, a system can be simplified.
[0018] Other examples of the electronic optical circuit which followed drawing 5 at the fifth mode of this invention are shown. In this example, one side of waveguide is optical amplification waveguide which has an optical amplifier function. although the ion to dope changes with wavelength to be used -- for example -- a 1.5-micron band -- Er ion and a 1.3-micron band -- Pr ion Tm ion can be used with 0.8-micrometer band. The light from semiconductor laser is amplified with pump light (for example, laser light with a wavelength of 0.98 microns), and let this be the decrease of supply of light (source of photoelectricity). It is equipped with optical devices, such as a photodiode (PD), and the electrode is formed in the optical circuit corresponding to the input/output terminal of IC. If such an optical circuit substrate is equipped with IC, according to the electrical potential difference of the output terminal of IC, the refractive-index modulation of EO (electro-optics) polymer (by the polymer which shows the Pockels effect, a refractive index changes in proportion to an electrical potential difference) will arise, and most or some of source of photoelectricity of light will be taken up. This light is sent to the photodiode formed corresponding to other input pins, and is inputted into IC as an electrical signal by photo electric conversion. Signal luminous intensity here With 0.1-1mW order extent, if strong, electric magnification will become unnecessary, or it will end by magnification of a low amplification factor. Optical amplification waveguide may be put on the path of the lightwave signal after pickup with the optical switch. Moreover, the location of EO polymer may not be limited to the location of drawing, but may be formed in the waveguide layer, the cladding layer, or the layer of these both.
[0019] An example of an electronic optical circuit which followed drawing 6 at the third mode of this invention is shown. In the example of drawing 6 (A), (B), and (C), some ICs are carried, for example on a silicon wafer, and the optical circuit substrate of a multi chip module (MCM) is shown in it (refer to drawing 6 (A)). As shown in drawing 6 (B), two or more installation of these may be carried out on the mother board. The output of each of such MCM is connected to the Kushigata electrode, and the other end of the Kushigata electrode has fallen on the gland. The Kushigata electrode is prepared on waveguide, and as long as the electrode is built over waveguide, the thing of size small as much as possible is desirable. Moreover, the waveguide and/or the buffer layer under the Kushigata electrode can consist of electrooptic material with the Pockels effect, for example, an organic nonlinear optical crystal, (for example, pendant addition mold polymers, such as MNBA, and DAN, MNA, a principal chain mold

polymer, a conjugation polymer), an electro-optics polymer (it is (for example, Japanese Patent Application No. [No. (March 26, Heisei 3 application) 132448 / three to] like a publication)), a compound semiconductor (for example, superlattice of III-V group semi-conductor or an II-VI group semi-conductor), etc. In addition, a grating-like electrode is attached to a change of the Kushigata electrode, and an electrical potential difference can be applied between substrates.
[0020] According to applied voltage, the part or all carries out outgoing radiation of the guided wave light out of waveguide by refractive-index change produced with the output voltage of MCM. Through a holographic optical element, this light can be led to other optical circuit substrates, and photo electric conversion is carried out by the photo detector prepared in other optical circuit substrates, and it serves as an input of MCM. OEIC with which the photo detector and the amplifier circuit were monolithic-ized here (it is effective to use an optoelectronic integrated circuit (for example, for the photodetector and the electrical signal amplifying circuit to be formed in the monolithic).) Or if the substrates of MCM are semi-conductors, such as Si, a photodetector and an electrical amplification circuit can be built to a substrate. moreover -- once -- light -- a holographic optical element and a diffraction grating -- using -- guided wave light -- changing -- an optical switch and optical amplification components (for example, semi-conductor amplifier, waveguide amplifier, etc.) -- guiding -- after [predetermined processing] photo electric conversion -- you may carry out . Or after predetermined processing, outgoing radiation can be again carried out out of waveguide, and it can also guide to other optical circuit substrates. Furthermore, by putting a holographic optical element on the optical outgoing radiation section, the wave front of an outgoing radiation beam can be controlled and light can also be guided towards desired.

[0021] Although the example of drawing 6 (A) showed the optical transfer between the multi chip modules (MCM) which carried some ICs, drawing 7 is the example of the optical transfer between ICs. Since the principle is completely the same as drawing 6 , explanation is omitted. In this case, the output of IC was transmitted with light and it has told other ICs. Moreover, although the following contents are explained by the example of MCM, all are applied also between ICs.
[0022] Drawing 8 is the example of the optical supply gestalt to an optical circuit. There are installation from LD array, installation from a fiber, installation by equipping with LD on an optical circuit, etc. In addition, it may prepare on an optical circuit substrate as OEIC.
[0023] Drawing 9 is the example which carried out outgoing radiation of the light by the holographic optical element or the diffraction grating after modulation ******.
[0024] After switching drawing 10 with a matrix optical switch or a 1xN switch, outgoing radiation of it is carried out, and it is effective in switching wiring and increasing the degree of freedom of an operation. Moreover, the outgoing radiation point can be chosen also by preparing the outgoing radiation section in multistage. In this case, if the period of a grating is changed, an outgoing radiation angle will become controllable.
[0025] In drawing 11, MCM and a holographic optical element are intermingled on a mother board. It is also possible to insert a holographic optical element between mother boards like drawing 12.
[0026] An example of the fourth mode of this invention is shown in drawing 13. In this mode, the optical switch (optical circuit element) to which mode transformation and optical-path conversion can be changed is offered in each location of an optical circuit using the Pockels effect or the optical Kerr effect. The multilayer waveguide bottom is a multimode (or the direction of a field multimode), and the bottom is single mode waveguide. Waveguide and/or a buffer (clad) layer are nonlinear optics waveguides, and have switched most or a part of light to the upper layer from the lower layer. Since this optical waveguide is multimode waveguide, the light which shifted to the upper optical waveguide 1 can enlarge waveguide deflection. As long as the ingredient of optical waveguide is a non-linear optical material which the switch section described above, passive waveguide is sufficient as others. Optical waveguide 2 is a single mode and drawing 14 is the example of three layers which optical waveguides 1 and 3 made the multimode. In this example, light is switched to optical waveguides 1 or 3 from optical waveguide 2. Contrary to [drawing 15] the example of drawing 13, the bottom is the example of a multimode. Thus, according to this invention, you may constitute so that light may shift between

[some / at least] a part of optical waveguide [at least] which could form optical waveguide in the shape of a multilayer on the substrate, and was prepared in the multilayer up layer, and the optical waveguide prepared in the lower layer. Moreover, it cannot be overemphasized that it is possible for multilayer structure to have been shown or to carry out same actuation in the usual planar structure in these examples. Moreover, it is not limited to the switch said from a single to multi. The switch to n mode (n> 3) waveguide from speed waveguide is also possible.

[0027] Drawing 16 and 17 are the examples which were adapted for the optical interconnection. According to these examples, the lightwave signal according to the output voltage of IC can be transmitted by making an optical switch correspond to the output terminal of an electronic device, and forming an optical circuit substrate by the optical shift to the channel waveguide or channel waveguide from slab mold waveguide from a channel waveguide.

[0028] Drawing 18 is an example which makes an optical-path change of the light of wavelength lambda by the waveguide hologram. As shown in drawing, if the example of drawing 18 is explained, in this mode, optical waveguides 1, 2, and 3 will be arranged. There is especially no limitation in an optical waveguide ingredient. On a straight line, there are optical waveguides 1 and 2, they form the waveguide which counters, and form the 3rd waveguide 3 further. Moreover, although the waveguide lens is formed corresponding to the optical waveguides 1 and 2 which counter, the lens of the 3rd waveguide 3 is not necessarily required. If it lets a light coherent on the same wavelength pass here as shown in drawing 18 (A), a hologram will be made with those cross points. Consequently, the light lambda which carried out outgoing radiation of the light lambda which carried out outgoing radiation from the waveguide 3 of an opposite side from optical waveguide 2 conversely to optical waveguide 2 goes into the waveguide 3 of an opposite side. As mentioned above, a rapid optical-path change can be automatically made by using a hologram. The hologram formal field consists of a photosensitive ingredient, and can apply the usual hologram ingredient to this.

[0029] Furthermore, as shown in drawing 19, the mode transformation of a single/multi also becomes possible by performing a single mode for the optical waveguides 1 and 2 which oppose, and performing the process same as a multimode for the 3rd waveguide 3.

[0030] Drawing 20 and 21 consider as one waveguide instead of two waveguides which drawing 18 and 19 counter, it is the example in which the 3rd waveguide 3 which is not parallel to this was formed, and if they produce a hologram like drawing 18 and 19, optical-path modification, and the single / multimode conversion of them will be attained. Drawing 22 and 23 are the examples of optical-path modification between slab mold waveguide and a channel waveguide, and a single / multimode conversion, respectively. It cannot be overemphasized that a hologram formation field at least needs to be a hologram ingredient in these cases.

[0031] Drawing 24 is the example which used the above mode transformation functions, switched by the single mode, multi-ized this, and was single-mode-ized by conversion. By this, since it becomes single mode light at the time of photo electric conversion, the speckle effect which poses a problem by the multimode can be controlled effectively. In addition, as the above-mentioned waveguide ingredient or a hologram ingredient, a well-known common ingredient can be used conventionally. For example, the film used as the cladding layer of waveguide is formed on base materials (substrate), such as glass, silicon, and plastics. As an ingredient of the film which forms a cladding layer, the copolymer from the mixture of polymers, such as polyvinyl alcohol, polyvinyl acetate, polymethylmethacrylate, and poly trifluoroethylmethacrylate, and those polymers and the configuration monomer of this polymer etc. can be used. The above-mentioned polymer is dissolved in a solvent, and it applies with a spin coat etc., and a cladding layer is produced. [on a base material] Subsequently, the photosensitive ingredient of the refractive-index modulation mold which forms waveguide and a hologram in the upper layer is applied. As a photosensitive ingredient of a refractive-index modulation mold, until now, for example A photopolymer handbook, The volume on photopolymer gathering for friendly discussion, the Kogyo Chosakai Publishing issue, the first edition (1989), and 442-457 Page; NIKKEI NEW MATERIALS, The April 16, 1990 issue, 43-49 pages; An ingredient technique, Vol.2, 10 (1984), 1-17 pages, O plus E, No.133 (1990), and 105-116 Many proposals are made in the page etc. and these ingredients can be used

in this invention. For example, the ingredient which uses the polymer of a low refractive index, the monomer of a high refractive index, and a photopolymerization initiator as a component can be used. There are polymethylmethacrylate, polyvinyl acetate, etc. as a low refractive-index polymer. As a high refractive-index monomer, dibromo phenyl acrylate, TORIBUROMO phenyl acrylate, Pentabromophenyl acrylate, vinyl naphthalene, vinylcarbazole, There is mixture, such as trimethylolpropane triacrylate and neopentyl glycol diacrylate, and there is an initiator of an iron-Arlen complex system, an organic peroxide system, and a biimidazole system etc. as a photopolymerization initiator. The transparent film may be again formed in the upper layer of a film as a cladding layer with a low refractive index rather than a film.

[0032]

[Effect of the Invention] If this invention is followed as explained above, it can be used for the system which is rich in flexibility, and can realize the electronic optical circuit which can respond to a complicated interconnection, and uses optical circuits, such as optical exchange and optical communication, in common.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the drawing in which an example of the conventional optical circuit is shown.
[Drawing 2] It is the drawing in which an example of the first mode of the electronic optical circuit of this invention is shown.
[Drawing 3] It is the drawing in which other examples of the first mode of the electronic optical circuit of this invention are shown.
[Drawing 4] It is the drawing in which an example of the second mode of the electronic optical circuit of this invention is shown.
[Drawing 5] It is the drawing in which other examples of the second mode of the electronic optical circuit of this invention are shown.
[Drawing 6] It is the drawing in which an example of the third mode of the electronic optical circuit of this invention is shown.
[Drawing 7] It is the drawing in which other examples of the third mode of the electronic optical circuit of this invention are shown.
[Drawing 8] It is the drawing in which the example of further others of the third mode of the electronic optical circuit of this invention is shown.
[Drawing 9] It is the drawing in which the example of further others of the third mode of the electronic optical circuit of this invention is shown.
[Drawing 10] It is the drawing in which the example of further others of the third mode of the electronic optical circuit of this invention is shown.
[Drawing 11] It is the drawing in which the example of further others of the third mode of the electronic optical circuit of this invention is shown.
[Drawing 12] It is the drawing in which the example of further others of the third mode of the electronic optical circuit of this invention is shown.
[Drawing 13] It is the drawing in which an example of an optical switch according to the fourth mode of this invention is shown.
[Drawing 14] It is the drawing in which other examples of the optical switch of this invention are shown.
[Drawing 15] It is the drawing in which the example of further others of the optical switch of this invention is shown.
[Drawing 16] It is the drawing in which the example of further others of the optical switch of this invention is shown.
[Drawing 17] It is the drawing in which the example of further others of the optical switch of this invention is shown.
[Drawing 18] It is the drawing in which the example of further others of the optical switch of this invention is shown.
[Drawing 19] It is the drawing in which the example of further others of the optical switch of this invention is shown.

[Drawing 20] It is the drawing in which the example of further others of the optical switch of this invention is shown.
[Drawing 21] It is the drawing in which the example of further others of the optical switch of this invention is shown.
[Drawing 22] It is the drawing in which the example of further others of the optical switch of this invention is shown.
[Drawing 23] It is the drawing in which the example of further others of the optical switch of this invention is shown.

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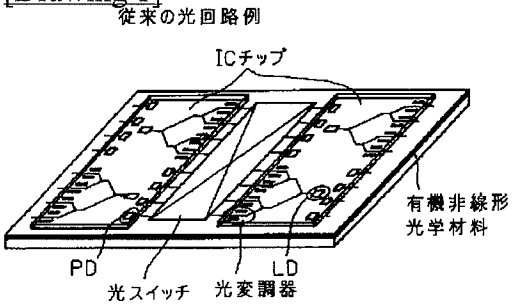
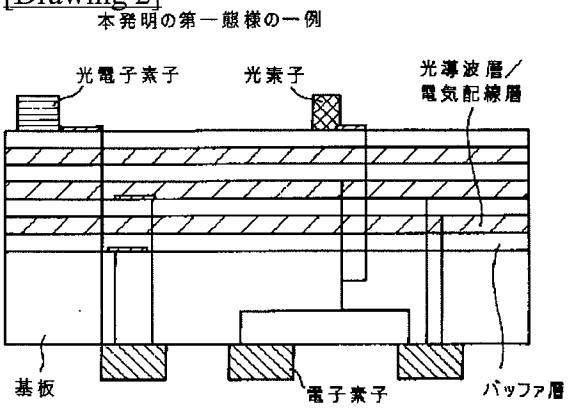
DRAWINGS

[Drawing 1]



[Drawing 2]



[Drawing 3]

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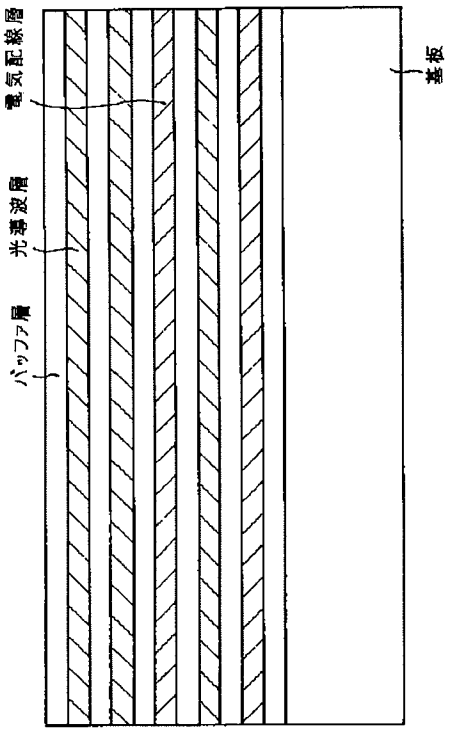
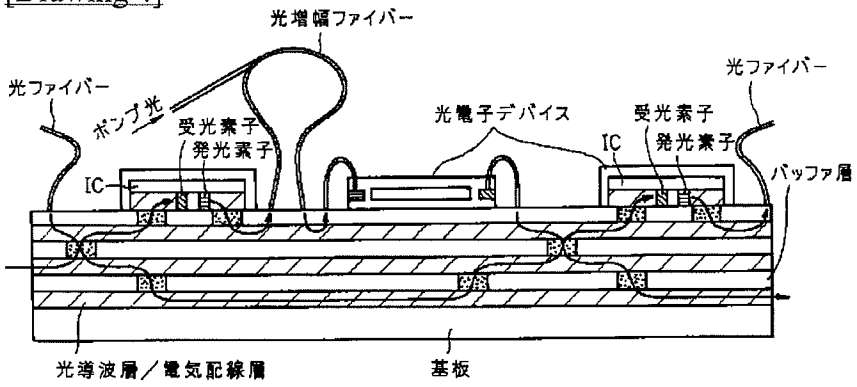
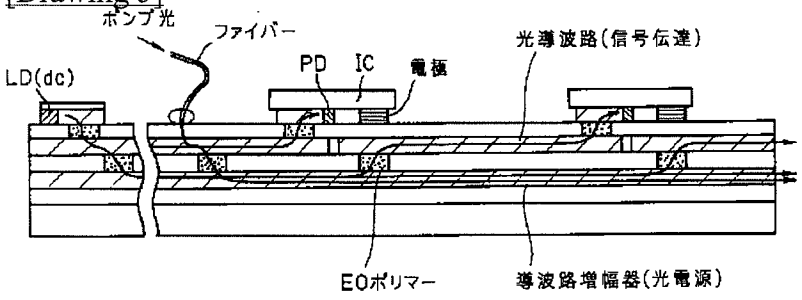


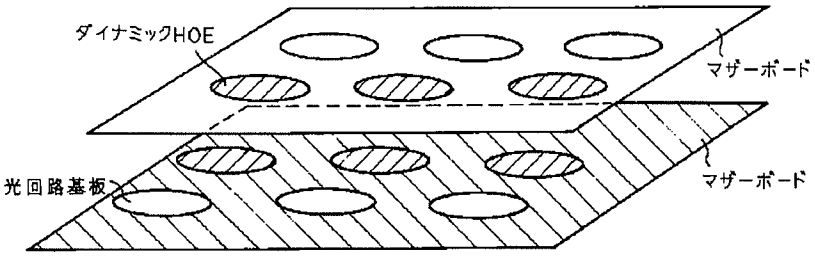
[Drawing 4]



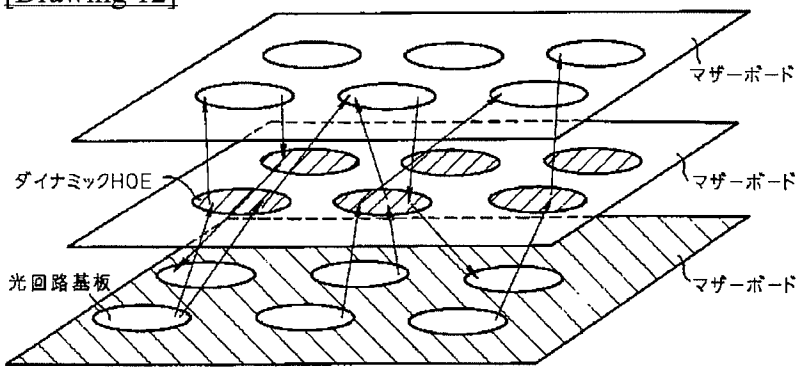
[Drawing 5]



[Drawing 11]

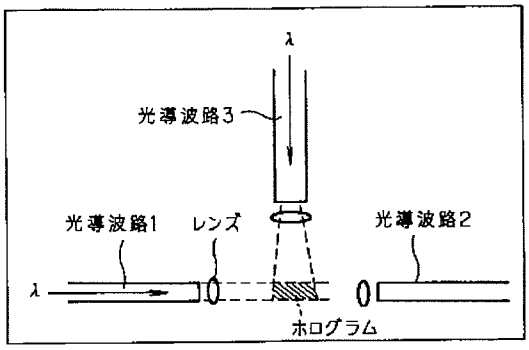


[Drawing 12]

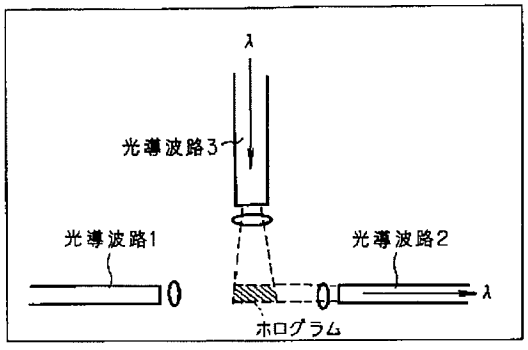


[Drawing 18]

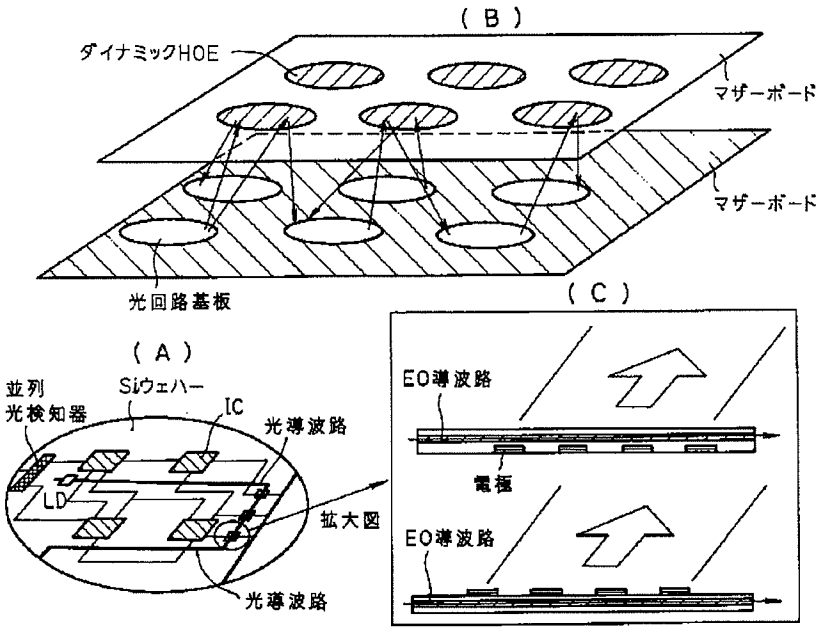
（Ａ）ホログラム作製プロセス



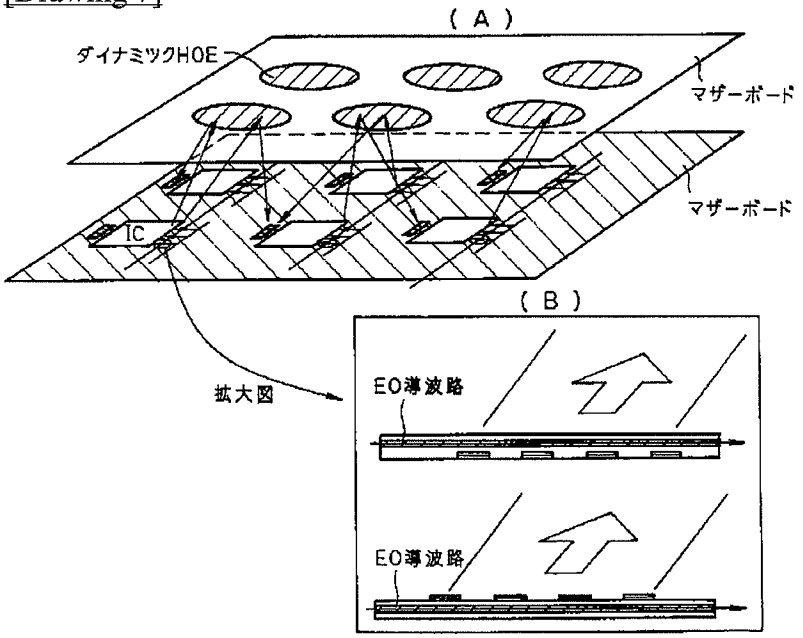
（Ｂ）光路変換



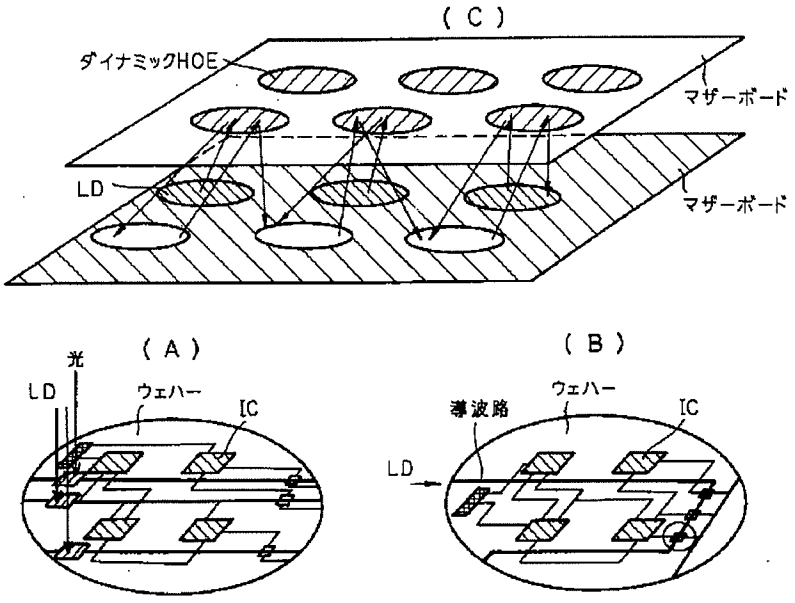
[Drawing 6]



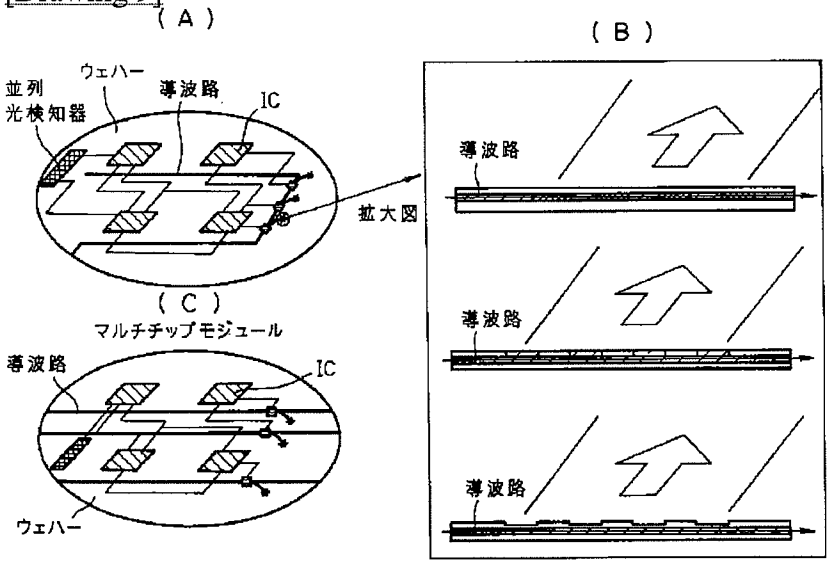
[Drawing 7]



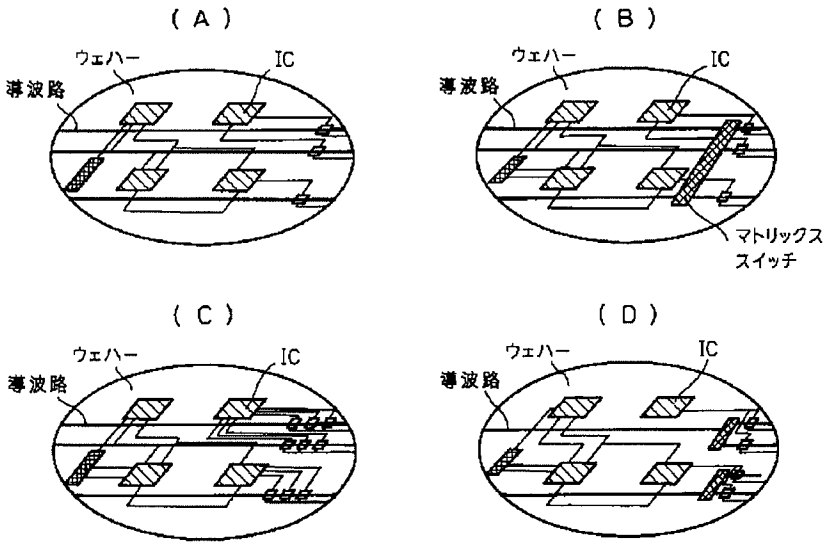
[Drawing 8]



[Drawing 9]

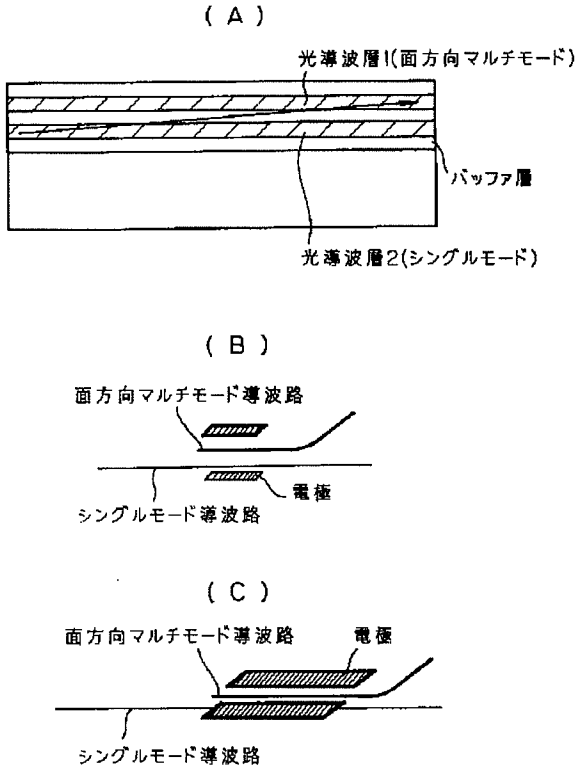


[Drawing 10]

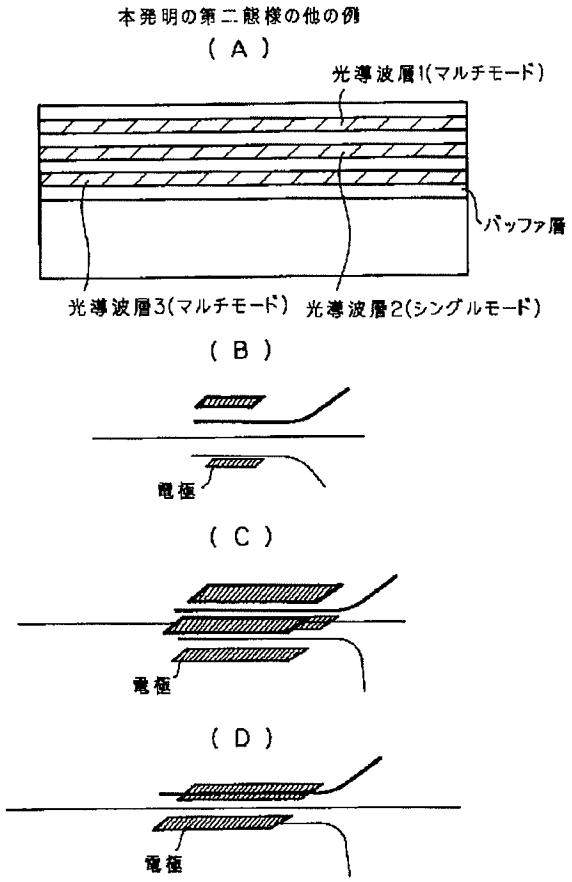


[Drawing 13]

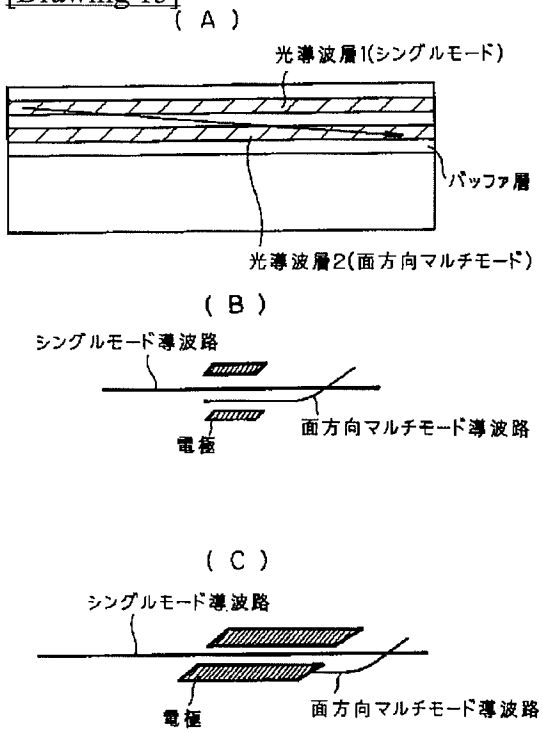
本発明の第二態様の一例



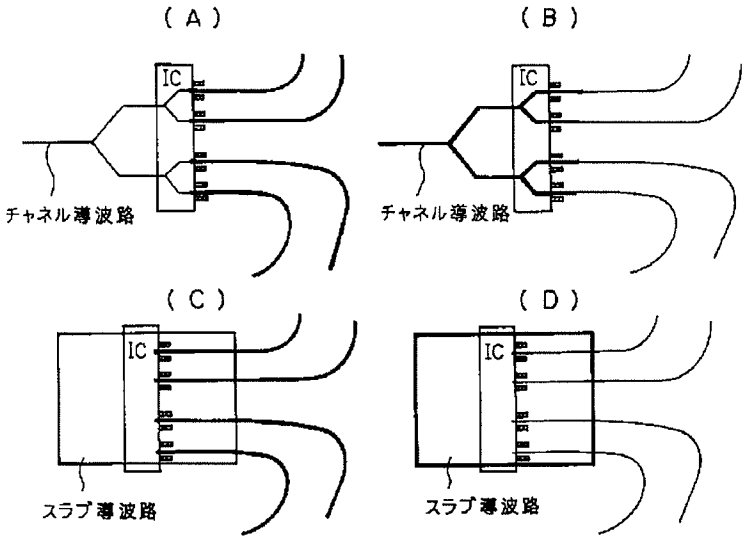
[Drawing 14]



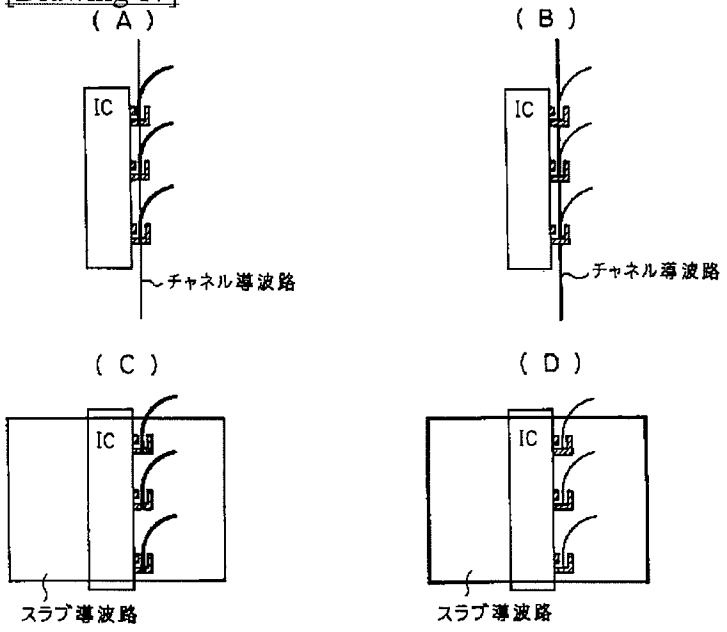
[Drawing 15]



[Drawing 16]

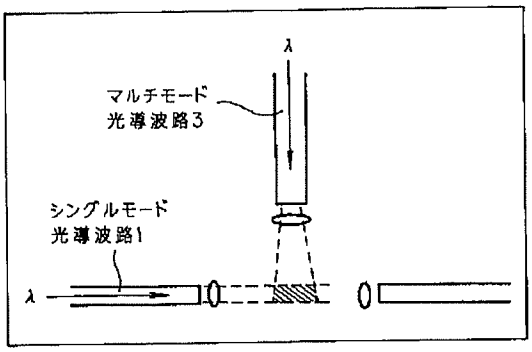


[Drawing 17]

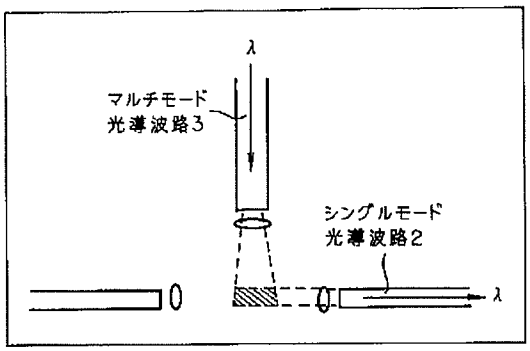


[Drawing 19]

（Ａ）ホログラム作製プロセス

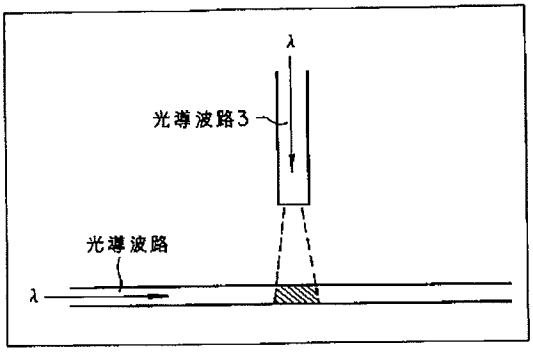


（Ｂ）シングル／マルチモード変換

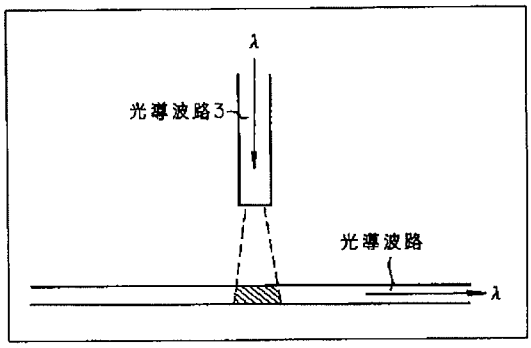


[Drawing 20]

（Ａ）ホログラム作製プロセス

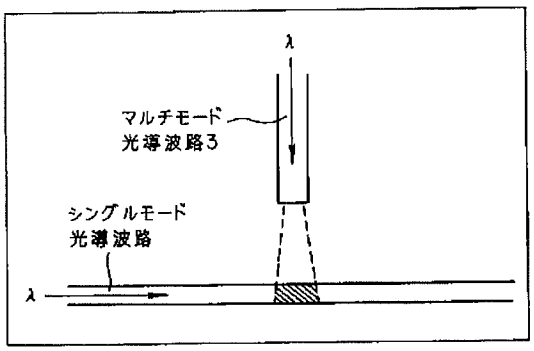


（Ｂ）光路変換

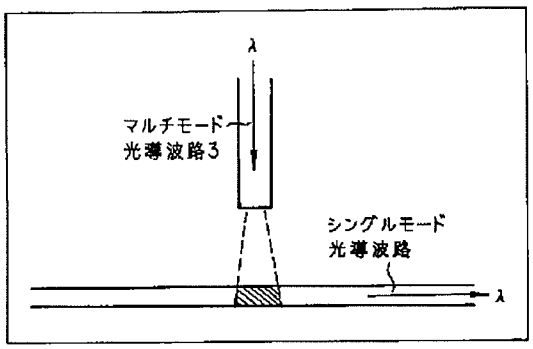


[Drawing 21]

（Ａ）ホログラム作製プロセス

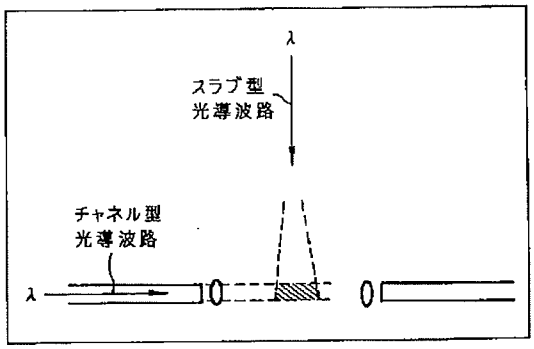


（Ｂ）シングル／マルチモード変換

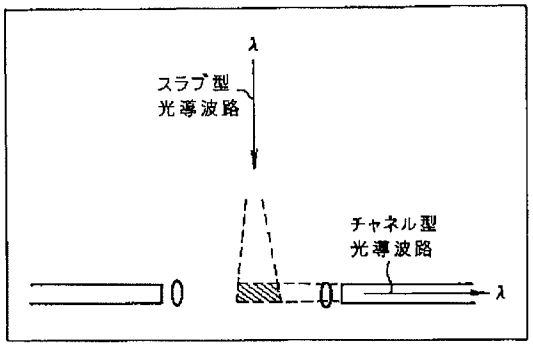


[Drawing 22]

（Ａ）ホログラム作製プロセス

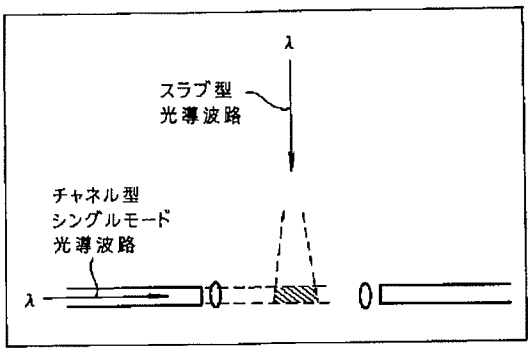


（Ｂ）光路変換

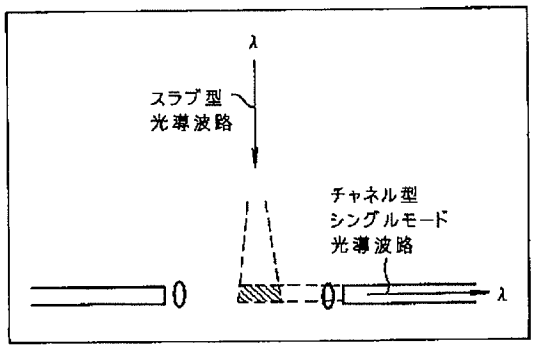


[Drawing 23]

（Ａ）ホログラム作製プロセス



（Ｂ）モード変換



[Translation done.]